DRIVING METHOD FOR LIQUID CRYSTAL ELECTROOPTIC ELEMENT

Patent Number: JP1277219
Publication date: 1989-11-07
Inventor(s): ITO AKIHIKO
Applicant(s): SEIKO EPSON CORP
Requested Patent: JP1277219
Application Number: JP19880106064 19880428
Priority Number(s):
IPC Classification: G02F1/133; C09G3/36
EC Classification:
Equivalents:

Abstract

PURPOSE:To eliminate differences of the visual angle among colors and to extend the visual angle by correcting the effective voltage applied to a liquid crystal electrooptic element in accordance with the characteristic for each color.

CONSTITUTION:The driving voltage of a signal electrode waveform is changed for each color to correct differences of threshold voltage among respective colors, and driving is performed in accordance with the threshold voltage of each color. The voltage of the signal electrode waveform applied to the color having the worst sharpness is set as an optimum bias and is set to the highest voltage because the threshold voltage of this color is highest, and the voltage of the signal electrode waveform applied to the color having the second worst sharpness is set to the second highest voltage because the threshold voltage of this color is highest but one, and the voltage of the signal electrode waveform applied to the color having the best sharpness is set to the lowest voltage and the on-off ratio of the applied voltage is reduced because the threshold voltage of this color is lowest. The difference of threshold voltage and the difference of sharpness among colors are corrected by this driving. Thus, the range of the visual angle is extended, and the difference of visual angle among colors is reduced.

Japanese Patent Laid-Open Publication No. Hei 1-277219

1. Title of the invention

DRIVING METHOD FOR LIQUID CRYSTAL ELECTRO-OPTICAL DEVICE

2. Claims

(1) A method for driving a liquid crystal electro-optical device, the device comprising:

a liquid crystal element having a twisted nematic liquid crystal sandwiched between two opposing electrode substrates and also having a color filter disposed on an inner surface of one of the substrates;

at least one layer of optically anisotropic material; and

a pair of polarizing plates disposed on outer sides of and sandwiching the liquid crystal elements and the optically anisotropic material,

wherein an effective voltage to be applied to the liquid crystal electro-optical device is corrected to match with characteristics varying with colors, based on differences between color-specific electro-optical characteristics in the liquid crystal electro-optical device.

(2) A method for driving the liquid crystal electro-optical device according to claim 1, wherein differences between color-specific threshold voltages in the liquid crystal electro-optical device are corrected.

Received Aug-20-03 01:45am From-0422 21 2431 To-Hogan & Hartson L.L. Page 020

(3) A method for driving the liquid crystal electro-optical device according to claim 1, wherein differences between color-specific threshold voltages in the liquid crystal electro-optical device and differences between steepnesses as one of the electro-optical characteristics are corrected.

3. Detailed Explanation of the Invention

[Technical Field of the Invention]

The present invention relates to a liquid crystal electro-optical device, and, in particular, to the displaying of color.

[Description of the Prior Art]

A liquid crystal device according to a conventional neutralized twisted nematic mode (hereinafter, referred to as an NTN mode) uses a driving method designed to eliminate coloring specific to a super-twisted nematic mode, thereby enabling black and white displaying.

[Problems to be solved by the Invention]

When color display is performed by incorporating color filters into the above-mentioned NTN mode based liquid crystal device, and when a voltage of a driving waveform similar to that for black and white displaying is applied, the electro-optical characteristics differ among colors, as shown in Fig. 3.

As a result, it is inevitable that viewing angles vary with colors, such as is shown in Fig. 2(a). In Fig. 2(a), vertical and lateral axes represent viewing angles, and lines 201, 202, and 203 represent ranges of viewing angles, respectively, for green, red, and blue colors (any

line represents the case where the contrast ratio is 1:10 or more). Additionally, as is clear from Fig. 2(a), there is a problem in that the viewing angles are reduced.

The present invention was conceived to solve the above-described problems. An object of the present invention is to provide a method for driving a liquid crystal electro-optical device in which differences between viewing angle variations in colors are eliminated and the viewing angles widen.

[Means for solving the Problems]

The present invention provides a method for driving a liquid crystal electro optical device, the device comprising a liquid crystal element having a twisted nematic liquid crystal sandwiched between two opposing electrode substrates and also having a color filter disposed on an inner surface of one of the substrates, at least one layer of optically anisotropic material, and a pair of polarizing plates disposed on outer sides of and sandwiching the liquid crystal elements and the optically anisotropic material, wherein an effective voltage to be applied to the liquid crystal electro-optical device is corrected to match with characteristics varying with colors, based on differences between color-specific electro-optical characteristics in the liquid crystal electro-optical device.

[Preferred Embodiments]

Fig. 4(a) is a cross-sectional view of a liquid crystal electro-optical device according to the present invention, and Fig. 4(b) is a diagram showing an example of relationship between axes. Reference numerals 401, 402, 403, and 404 represent an upper polarizing

Received Aug-20-03 01:48am From-0422 21 2431 To-Hogan & Hartson L.L. Page 022

plate, a display cell, a compensation cell, and a lower polarizing plate, respectively. Angles are set so that an angle 428 is 210 degrees to the left, an angle 430 is 210 degrees to the right, an angle 427 is 45 degrees to the left, an angle 429 is 90 degrees, and an angle 431 is 45 degrees to the left. Electro-optical characteristics in the liquid crystal electro optical device are shown in Fig. 3. As shown in Fig. 3, a threshold voltage, indicated by 301, for blue color is the lowest, Vth = 1.93 (V). The next lowest is a threshold voltage, indicated by 302, for green, Vth = 1.95 (V). The highest threshold voltage is the one for red, indicated by 303, Vth = 1.98 (V). As for steepness, a curve for blue indicated by 301 is the steepest, a curve for green is the next steepest, and a curve for red is the least steep.

The above described liquid crystal electro-optical device is multiplex driven according to a driving waveform shown in Fig. 1(b) with a duty cycle of 1/100.

Fig. 1(a) is a diagram showing an electrode configuration of the liquid crystal element. Reference numerals 101 and 102 represent scanning electrodes. Reference numerals 103, 104, and 105 represent signal electrodes, respectively, on a red filter, on a green filter, and on a blue filter. The driving waveform shown in Fig. 1(b) is applied to each of the electrode. A driving waveform shown by a scanning electrode waveform 107 is applied to the scanning electrode 101. A red signal electrode waveform 108 is applied to the signal electrode 103, a green signal electrode waveform 109 is applied to the signal electrode 104, and a blue signal electrode waveform 110 is applied to the signal electrode 105. The shapes of these signal electrode

Received Aug-20-03 01:45am From-0422 21 2431 To-Hogan & Hartson L.L. Page 023

waveforms change with contents to be displayed. Effective voltages applied to the respective pixels cause the liquid crystal elements to turn on or off. In Fig. 1(b), t_1 and t_4 are ON pulses, and t_2 and t_3 are OFF pulses.

Next, an example of a method for correcting differences between the electro optical characteristics varying with colors will be described. Because, as shown in Fig. 3, the threshold voltage for red is the highest and the curve is the least steep, the voltage to be applied according to the red signal electrode waveform 108 is set to be an optimum bias for securing the largest on-to-off ratio. The voltage according to the green signal electrode waveform is set to be lower than the voltage for red, and the voltage according to the blue signal electrode waveform is set to be lower than the voltage for green. Driving voltage conditions for the present embodiment are set as follows:

$V_1 = 14.8$ (V) $\quad V_2 = -14.8$ (V)

$V_3 = 1.48$ (V) $\quad V_4 = -1.48$ (V)

$V_5 = 1.43$ (V) $\quad V_6 = -1.43$ (V)

$V_7 = 1.40$ (V) $\quad V_8 = -1.40$ (V)

Thus, the driving voltages of the signal electrode waveforms are changed with the respective colors, so that the differences between the threshold voltages for the respective colors are corrected and the liquid crystal electro-optical device is driven with the threshold voltages for the respective colors. Further, as the threshold voltage for the color with the least steep curve is the highest, the voltage to be applied according to the signal electrode waveform for the color with the least steep curve is set to be an optimum bias and also be the highest voltage.

As the color with the second steepest curve has the second highest threshold voltage, the voltage according to the signal electrode waveform is set to be the second highest voltage. As the threshold voltage for the color with the steepest curve is the lowest, the voltage to be applied according to the signal electrode waveform for the color with the steepest curve is set to be the lowest, thereby causing the applied voltage to have a smaller on-to-off ratio. By driving the liquid crystal device in this manner, the differences between the color-specific threshold voltages and the differences between the color-specific steepnesses are corrected.

Although, according to the present embodiment, the effective voltages to be applied to the liquid crystal elements are corrected by changing the voltages of the signal electrode waveforms, the effective voltages can be corrected by changing ON pulse widths in the signal electrode waveforms. Further, when gradation display is performed, the ON pulse width t_1 or t_4 may be divided into the number of levels of gradation to achieve halftone display.

[Advantages]

As described above, the present invention is advantageous in that the ranges of viewing angles are extended when compared with the ranges of viewing angles in the conventional driving method, with less difference between viewing angles varying with colors, and with less color shift due to change in direction of clear vision.

4. Brief Description of the Drawings

Fig. 1(a) shows an electrode configuration of a liquid crystal

electro-optical device according to an embodiment of the present invention, and Fig. 1(b) shows a driving waveform according to the embodiment of the present invention.

Fig. 2(a) is a diagram showing viewing angles of a liquid crystal electro-optical device according to a conventional driving method, and Fig. 2(b) is a diagram showing viewing angles of a liquid crystal electro-optical device according to the present invention. Figs. 2(a) and 2(b) both show ranges of vision with a contrast of 1:10 or more.

Fig. 3 is a graph showing electro-optical characteristics of the liquid crystal electro-optical device.

Fig. 4(a) is a cross-sectional view of the liquid crystal electro-optical device, and Fig. 4(b) is a diagram showing relationship between axes shown in Fig. 4(a).

101, 102 SCANNING ELECTRODE
103 SIGNAL ELECTRODE ON RED FILTER
104 SIGNAL ELECTRODE ON GREEN FILTER
105 SIGNAL ELECTRODE ON BLUE FILTER
106 PIXEL
107 SCANNING ELECTRODE WAVEFORM
108 RED SIGNAL ELECTRODE WAVEFORM
109 GREEN SIGNAL ELECTRODE WAVEFORM
110 BLUE SIGNAL ELECTRODE WAVEFORM
201 RANGE OF VIEWING ANGLES FOR GREEN
202 RANGE OF VIEWING ANGLES FOR RED
203 RANGE OF VIEWING ANGLES FOR BLUE

301 VOLTAGE-TRANSMITTANCE CHARACTERISTICS FOR BLUE
302 VOLTAGE-TRANSMITTANCE CHARACTERISTICS FOR GREEN
303 VOLTAGE-TRANSMITTANCE CHARACTERISTICS FOR RED
401 UPPER POLARIZING PLATE
402 LIQUID CRYSTAL CELL FOR DISPLAY (DISPLAY CELL)
403 OPTICALLY ANISOTROPIC MATERIAL, OR LIQUID CRYSTAL CELL AS OPTICALLY ANISOTROPIC MATERIAL (COMPENSATION CELL)
404 LOWER POLARIZING PLATE
405 UPPER SUBSTRATE OF DISPLAY CELL
406 COLOR FILTER
407 TRANSPARENT ELECTRODE
408 ALIGNMENT LAYER
409 LIQUID CRYSTAL OF DISPLAY CELL
410 LOWER SUBSTRATE OF DISPLAY CELL
411 UPPER SUBSTRATE OF COMPENSATION CELL
412 LIQUID CRYSTAL OF COMPENSATION CELL
413 LOWER SUBSTRATE OF COMPENSATION CELL
421 DIRECTION OF POLARIZATION AXIS (ABSORPTION AXIS) OF UPPER POLARIZING PLATE 401
422 RUBBING DIRECTION OF UPPER SUBSTRATE 405 OF DISPLAY CELL
423 RUBBING DIRECTION OF LOWER SUBSTRATE 410 OF DISPLAY CELL
424 RUBBING DIRECTION OF UPPER SUBSTRATE 411 OF COMPENSATION CELL
425 RUBBING DIRECTION OF LOWER SUBSTRATE 413 OF COMPENSATION CELL
426 DIRECTION OF POLARIZATION AXIS (ABSORPTION AXIS) OF LOWER

Received Aug-20-03 01:45am From-0422 21 2431 To-Hogan & Hartson L L Page 027

POLARIZING PLATE 404

427 ANGLE FORMED BETWEEN DIRECTION 421 OF POLARIZATION AXIS OF UPPER POLARIZING PLATE AND RUBBING DIRECTION 422 OF UPPER SUBSTRATE OF DISPLAY CELL

428 TWIST ANGLE OF LIQUID CRYSTAL 409 OF DISPLAY CELL

429 ANGLE FORMED BETWEEN RUBBING DIRECTION 423 OF LOWER SUBSTRATE OF DISPLAY CELL AND RUBBING DIRECTION 424 OF UPPER SUBSTRATE OF COMPENSATION CELL

430 TWIST ANGLE OF LIQUID CRYSTAL 412 OF COMPENSATION CELL

431 ANGLE FORMED BETWEEN DIRECTION 426 OF POLARIZATION AXIS OF LOWER POLARIZING PLATE AND RUBBING DIRECTION 425 OF LOWER SUBSTRATE OF COMPENSATION CELL

Received Aug-20-03 01:45am From-0422 21 2431 To-Hogan & Hartson L.L. Page 028